

# Aura Validation of Numerous Molecules using FIRS-2 Balloon Observations

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## FIRS-2 Capabilities

- High Resolution FTS, operates over most of Planck curve of the atmosphere, observing in limb geometry from balloons.
- The long wavelength end contains the MLS OH channel ( $80\text{ cm}^{-1}$ ).
- In the far infrared region, many of the same molecules measured by MLS have measurable rotational transitions, including  $\text{O}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{HDO}$ ,  $\text{H}_2^{18}\text{O}$ ,  $\text{H}_2^{17}\text{O}$ ,  $\text{HCl}$ ,  $\text{HF}$ ,  $\text{HOCl}$ ,  $\text{OH}$ ,  $\text{HO}_2$ ,  $\text{H}_2\text{O}_2$ ,  $\text{HBr}$ ,  $\text{HOBr}$ , and  $\text{NO}_2$ .
- At higher wavelengths, low frequency vibrational bands of heavier molecules are observable, including  $\text{CO}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{O}_3$ ,  $\text{HNO}_3$ ,  $\text{CFC11}$ ,  $\text{CFC12}$ ,  $\text{ClNO}_3$ ,  $\text{NO}_2$ ,  $\text{N}_2\text{O}_5$ , acetone, etc.. Many of the bands to those used by HIRDLS, TES and MIPAS and ACE.
- FIRS-2 makes measurements at all solar zenith angles and can cover an entire diurnal cycle during a balloon flight, providing a robust test of photochemistry.

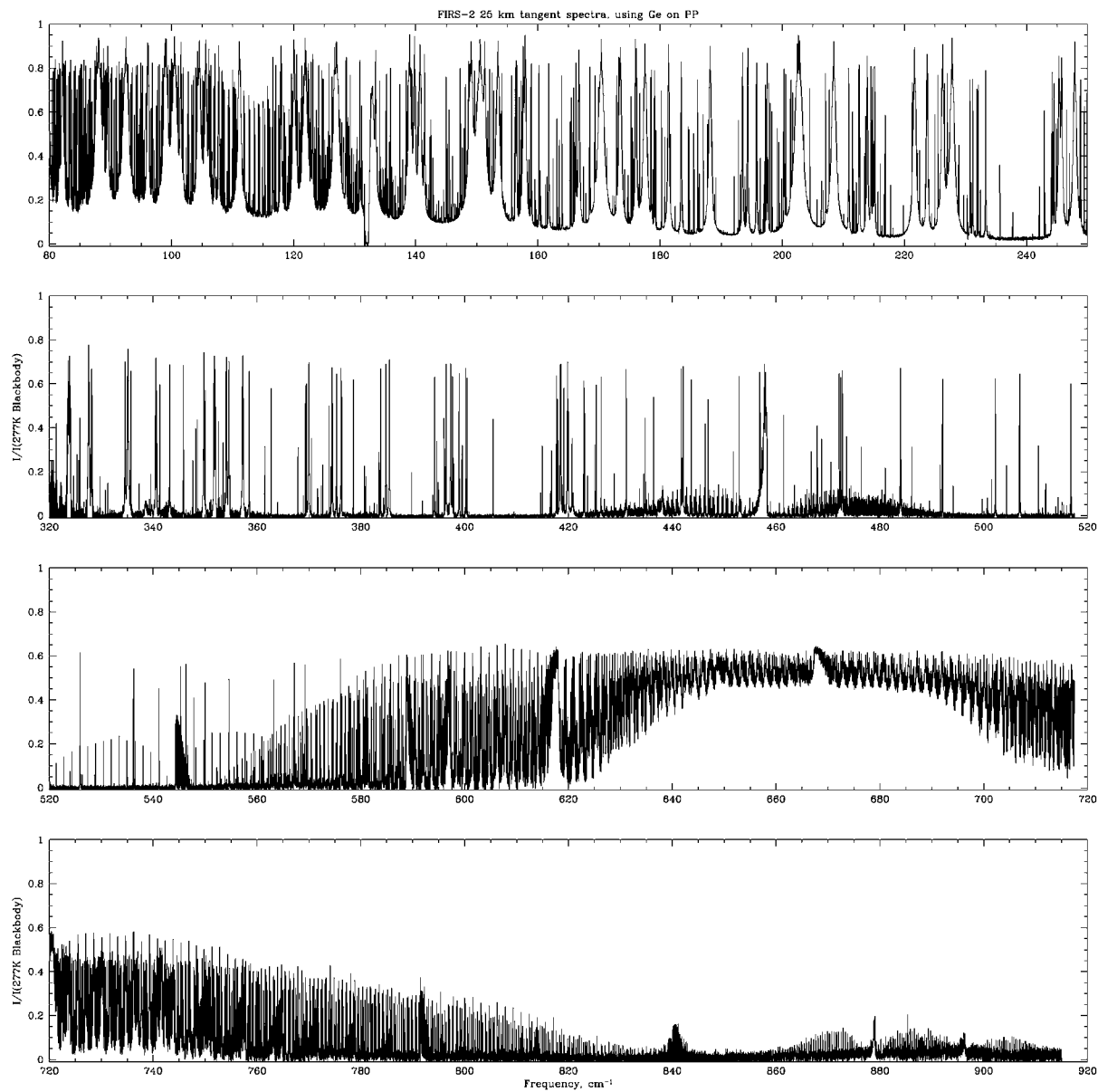
## Available Data, for Aura and other satellite missions

- May 1988
  - September 1989
  - June 1990
  - May 1992
  - September 1992
  - March 1993
  - May 1994
  - April 1997
  - September 2002
  - September 2003
  - September 2004
  - September 2005
- } UARS Validation flights
- } ILAS Validation flight
- } Data used for MIPAS validation
- } Aura Validation flights

# Specifics of Aura Validation Flights

- Flight origins from Fort Sumner, NM.
- Launch dates 23/09/2004 and 20/09/2005.
- Both flights lasted at least 18 hours at float.
- FIRS-2 made observations throughout both flights.
- 2004 flight has 9 FIRS-2 sets of profiles reported in AVDC archive file and day/night averages for selected files.
- 2005 flight has 18 sets of profiles reported in AVDC file and day/night averages for selected molecules.
- Both flights had the suite of JPL balloon instruments (stick around for both the SLS and MkIV talks...)
- Most MLS data shown will be 1 day zonal mean v2.1.
- Preliminary comparisons with HIRDLS have been shown during breakout groups or posters for HNO<sub>3</sub>, O<sub>3</sub>, and CFC11, CFC12

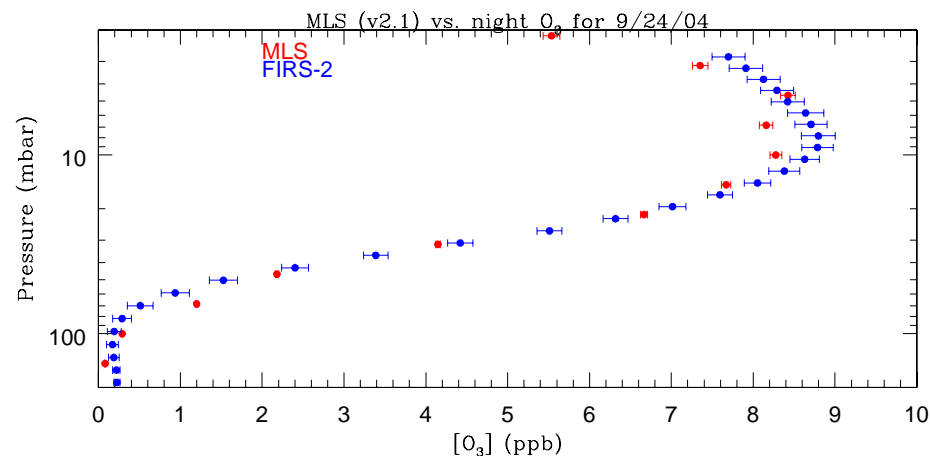
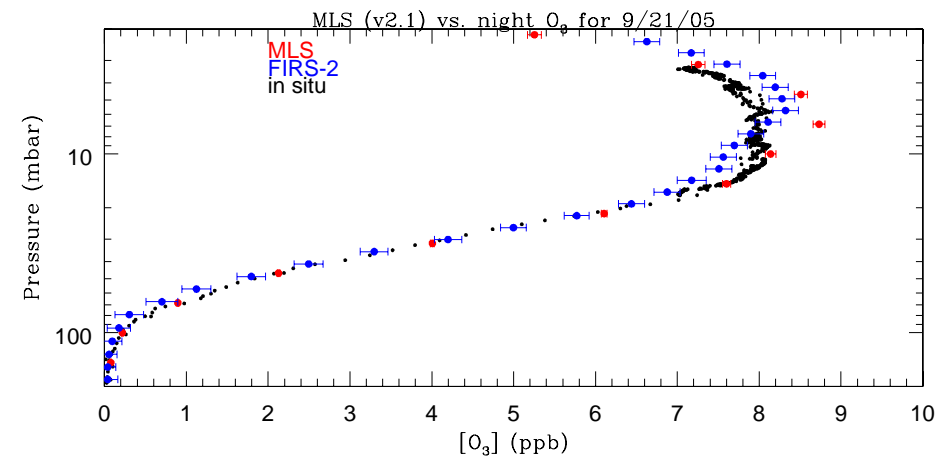
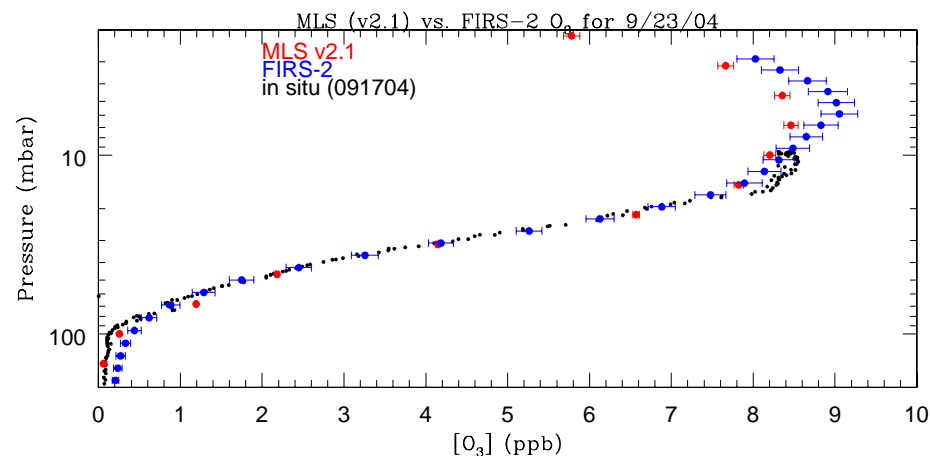
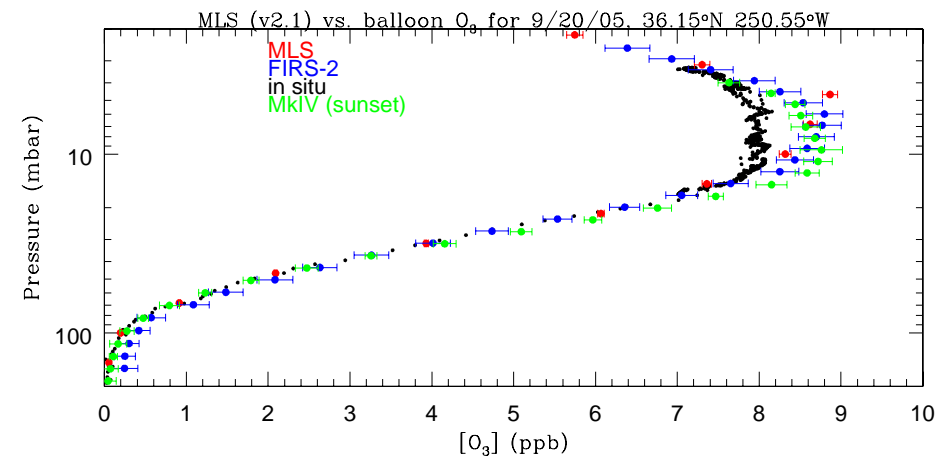
# Sample FIRS-2 spectrum



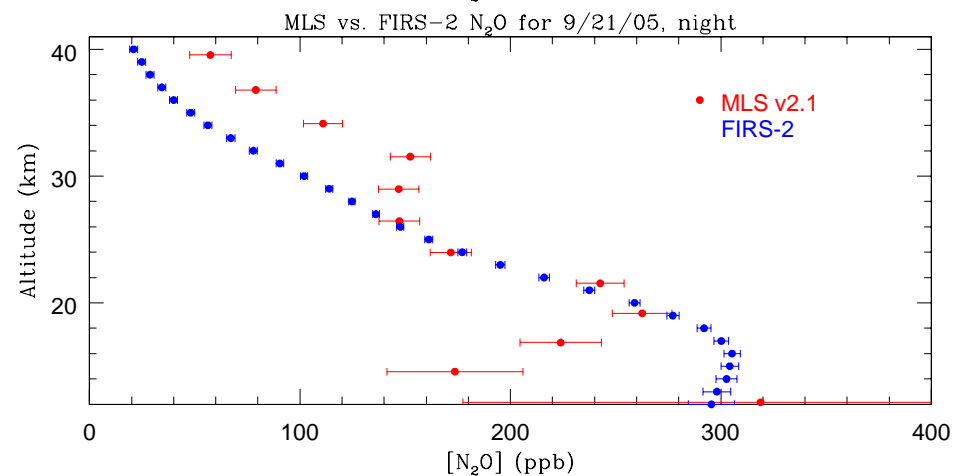
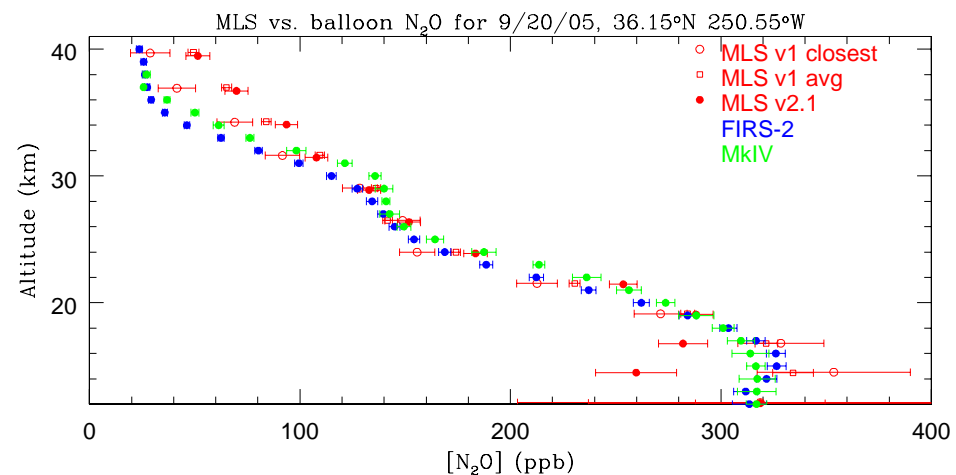
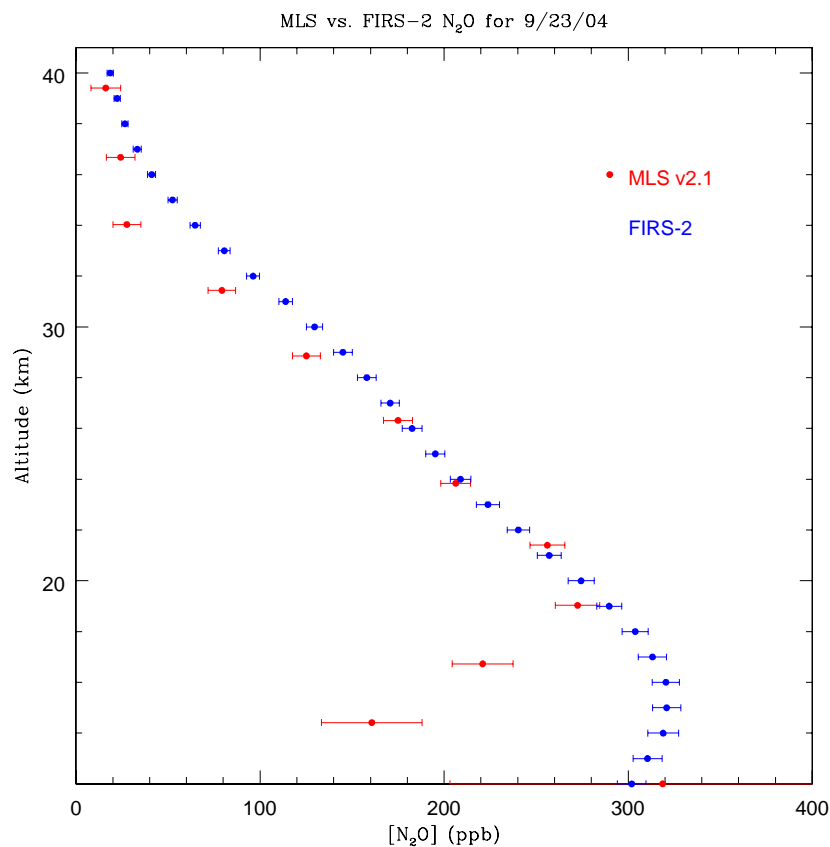
# Ozone Comparisons with MLS

September 2005

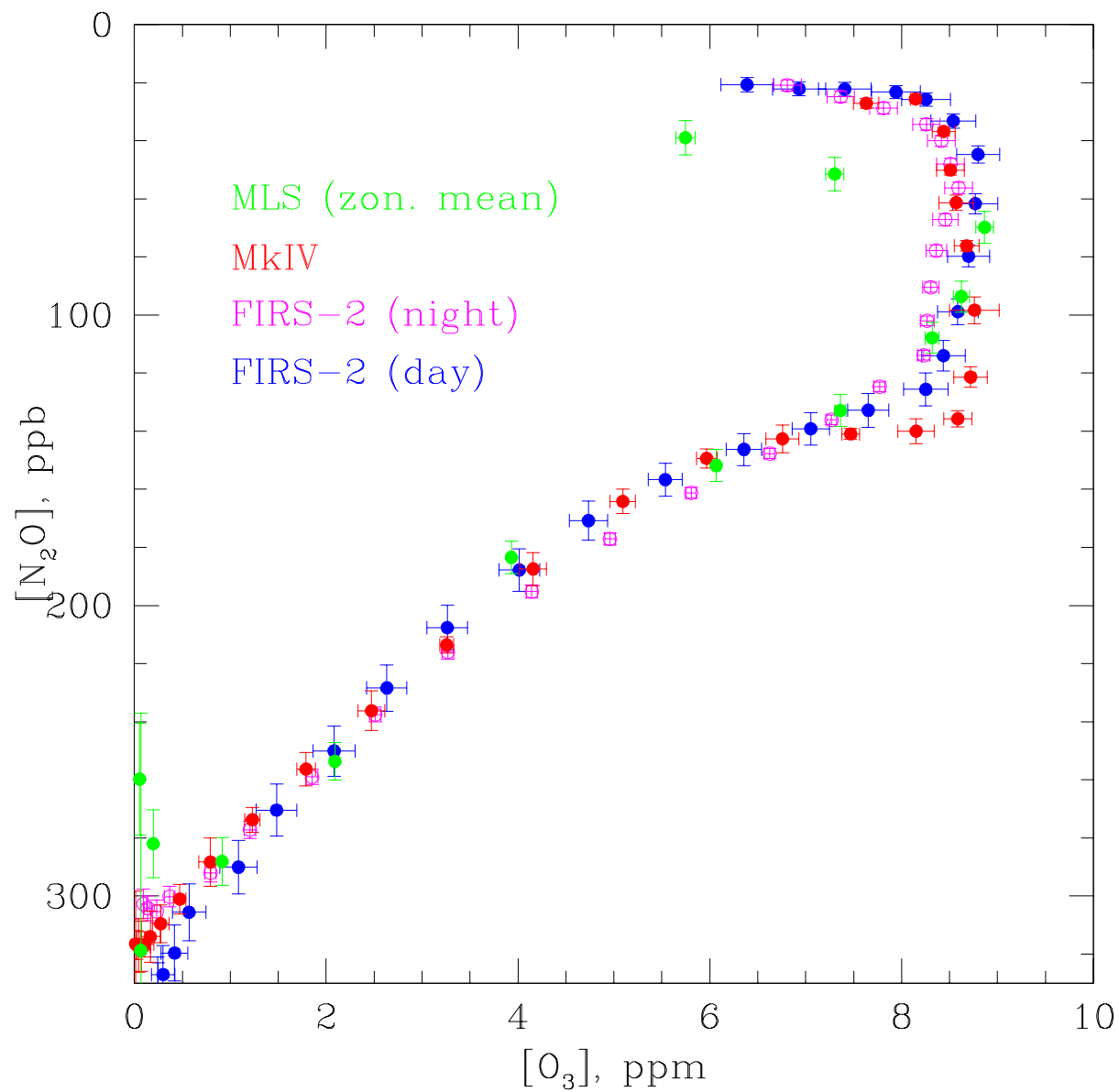
September 2004



# N<sub>2</sub>O retrievals

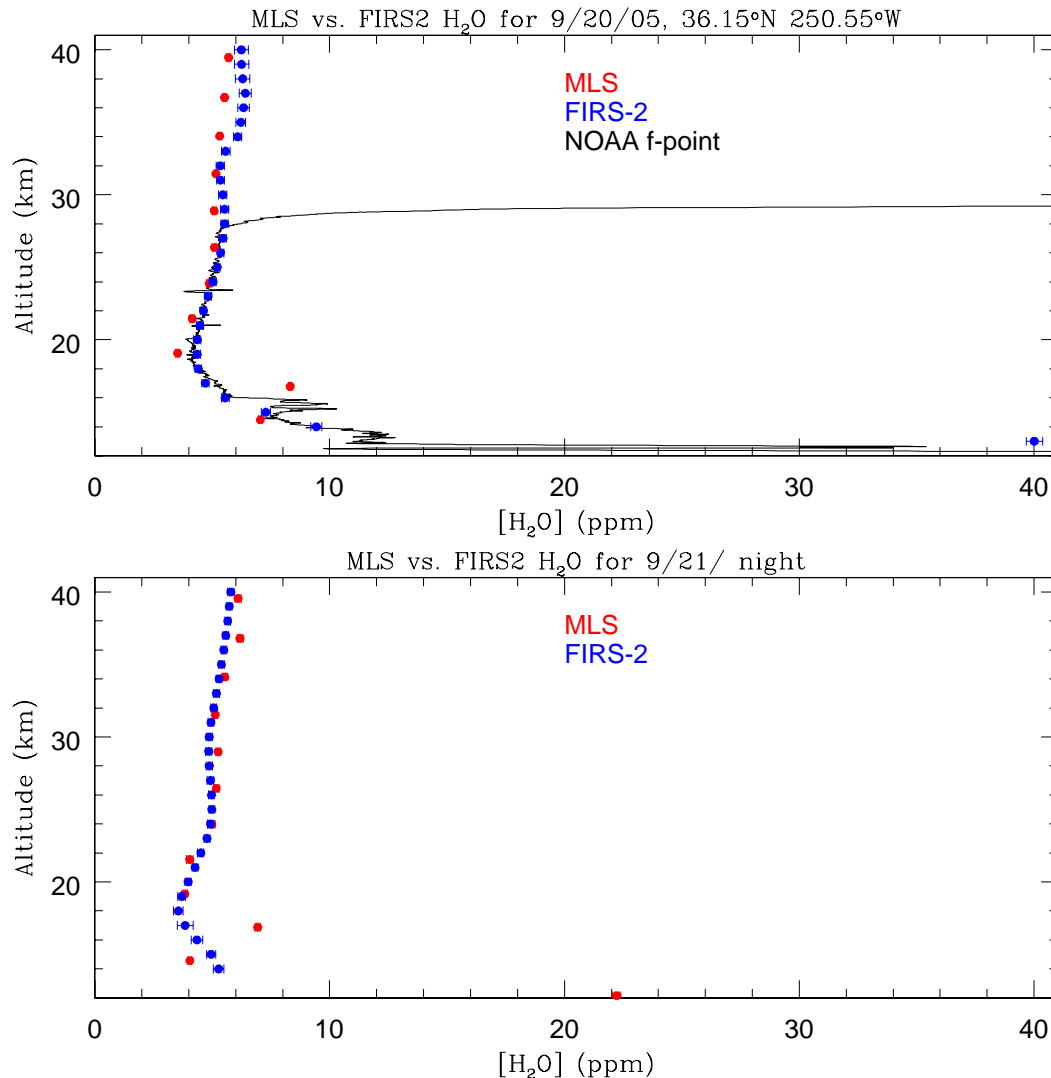


# N<sub>2</sub>O vs. O<sub>3</sub> Correlations





# Water vapor Comparison with MLS and Frost Point sonde



- FIRS-2 profile is the closest in time and location to MLS overpass.

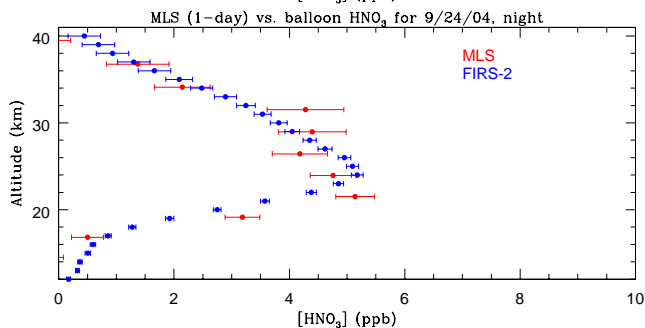
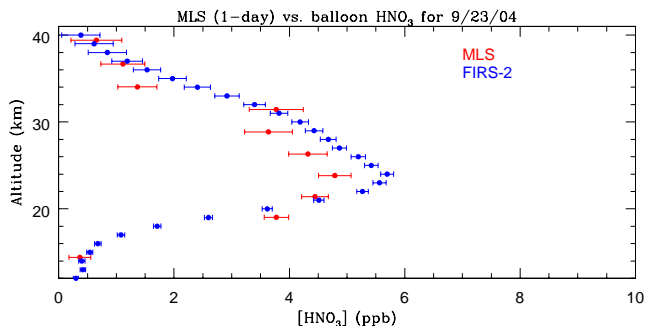
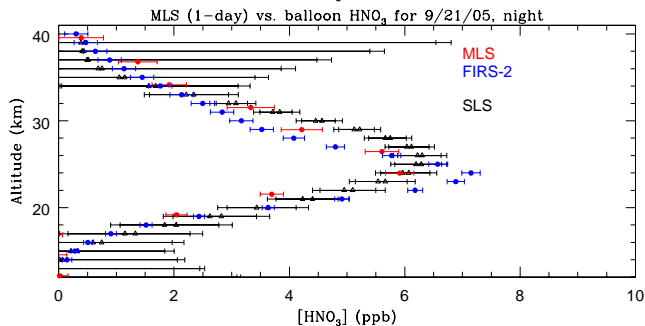
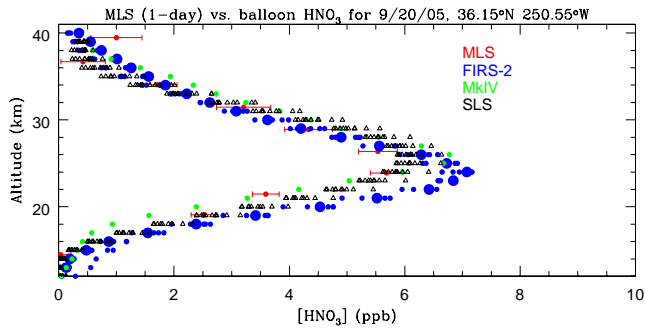
- Frost point sonde was launched from local airport here in Boulder the afternoon of the large balloon flight. The FIRS-2 profile closest to the time/place of the sonde compare similarly to this.

- The MkIV profile from sunset statistically agree with the FIRS-2 data. (Not shown here.)

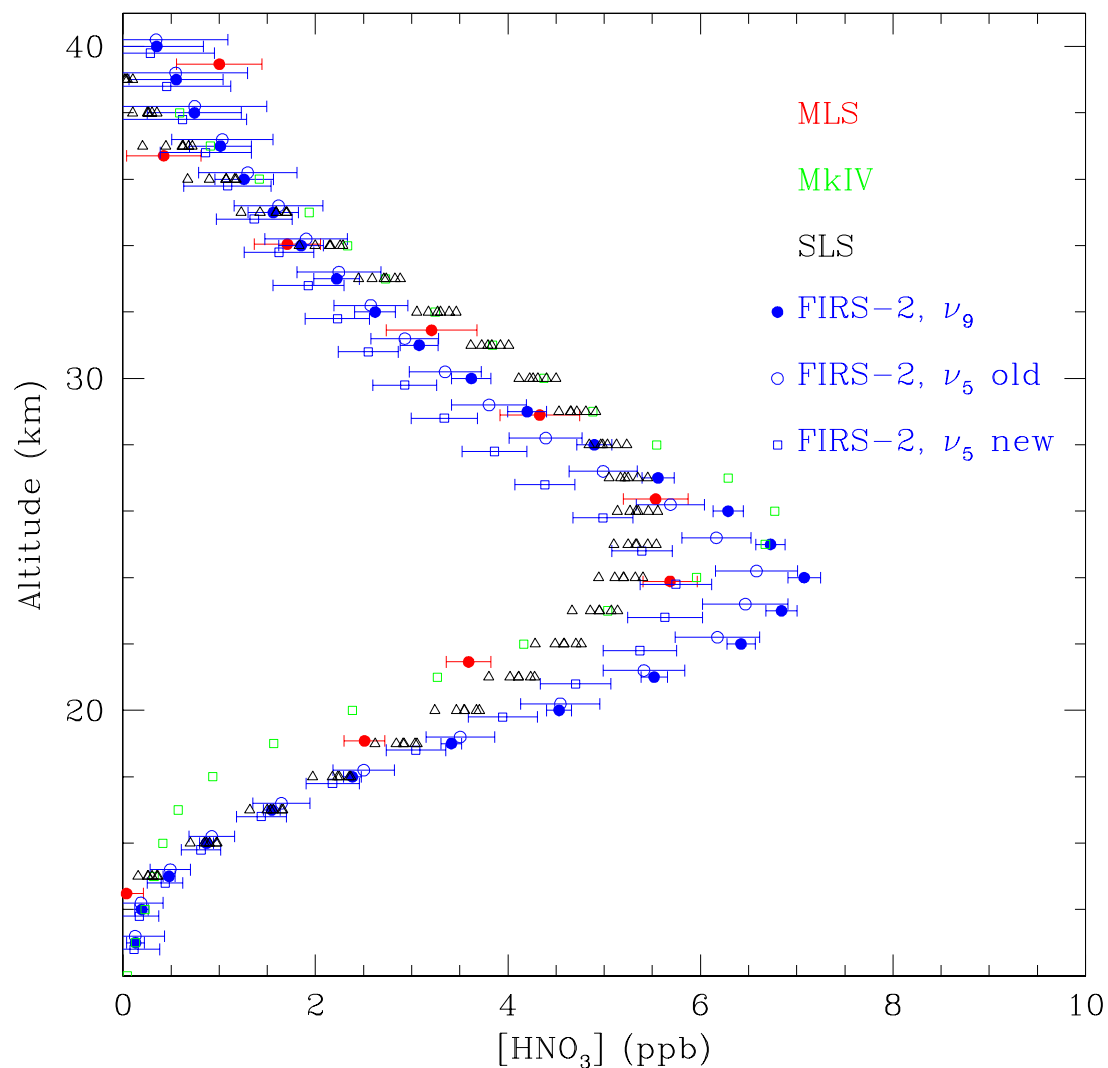
- FIRS-2 retrieves H<sub>2</sub>O profiles using rotational transitions in the THz region, and well into the far infrared.

# HNO<sub>3</sub> retrievals

- Many profiles from many instruments.
- FIRS-2 and SLS retrieve in the same air mass, MkIV is viewing at 90° CCW from that.
- The azimuth observational direction of the observations changes during the flight to coordinate with both the Aura footprint and to ensure MkIV points at the sun for occultations.

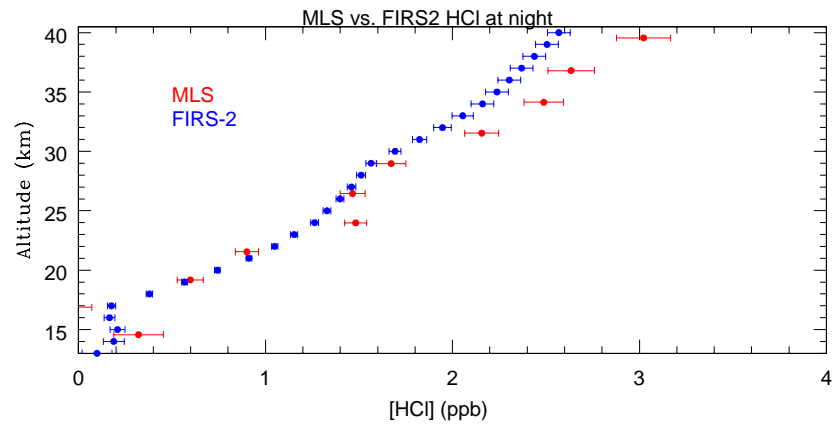
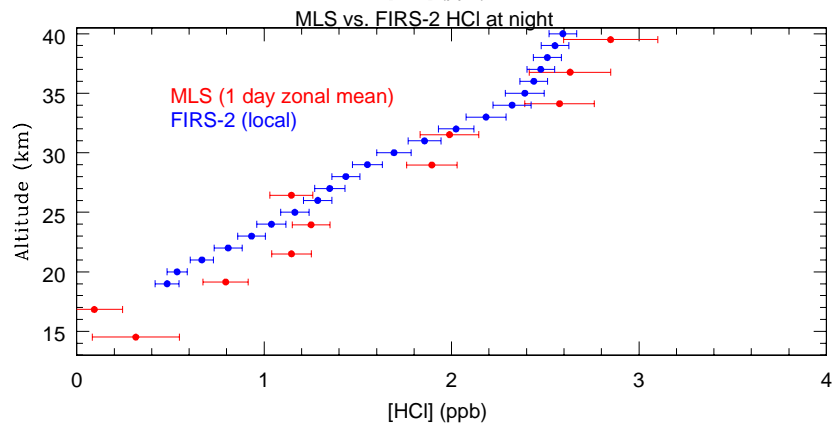
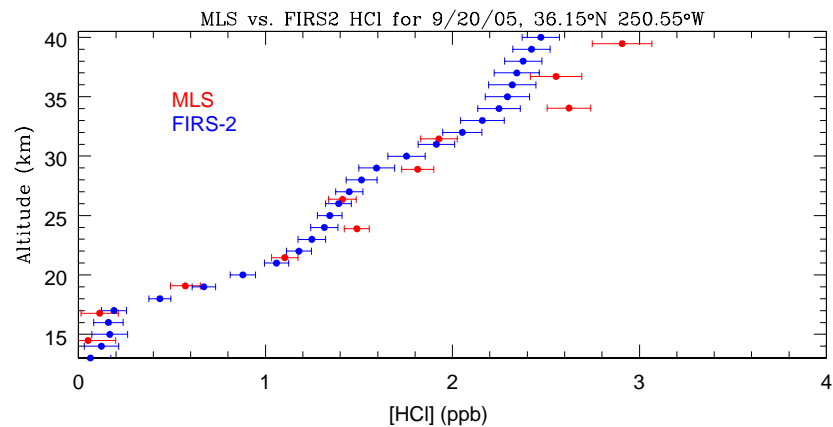
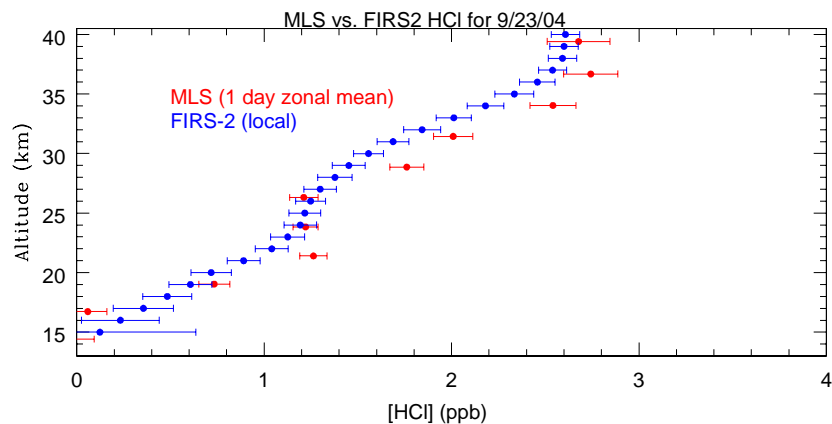


MLS (1-day) vs. balloon  $\text{HNO}_3$  for 9/20/05, 36.15°N 250.55°W

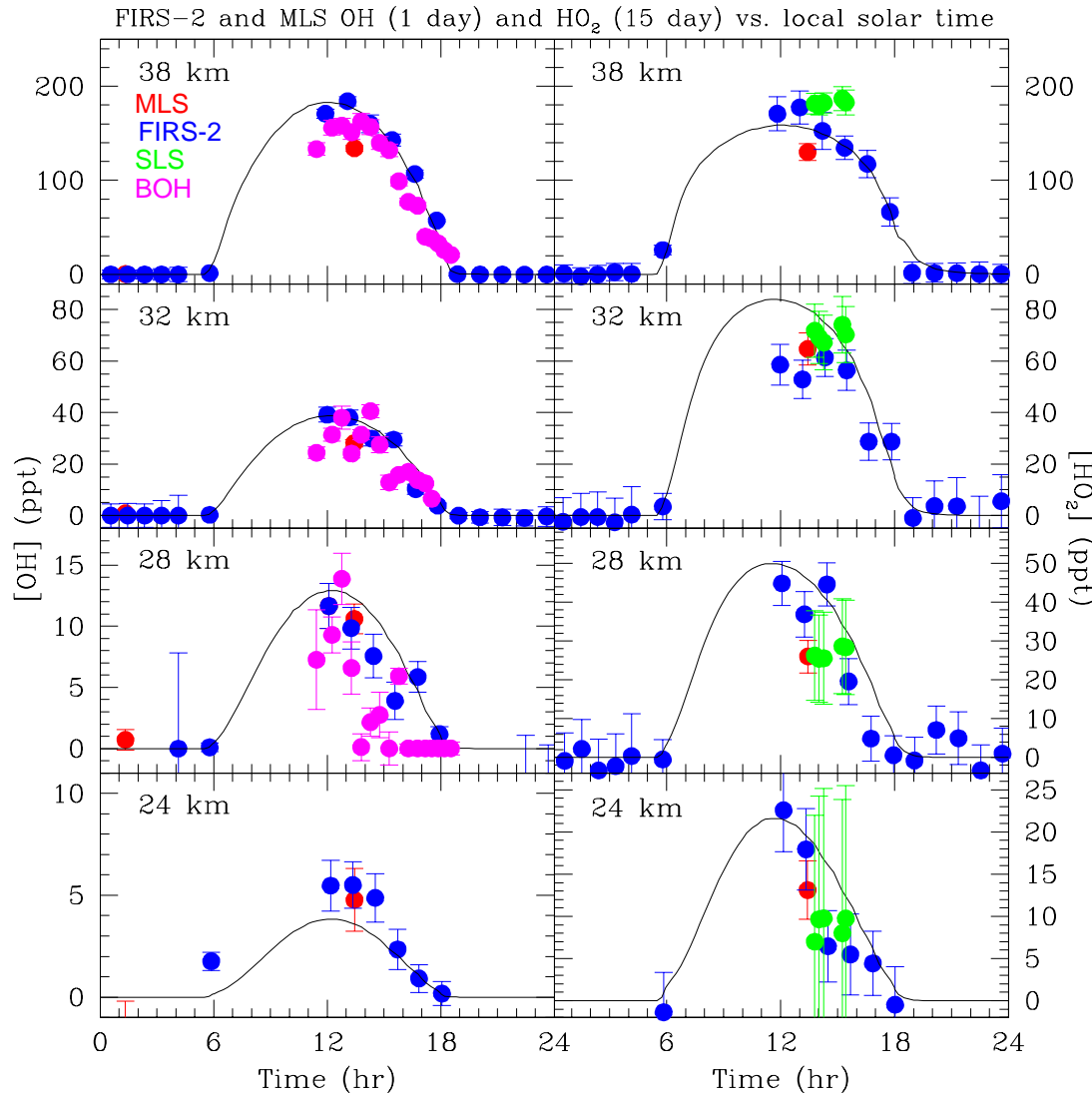


- All instruments measure with different bands or lines.
- MLS and SLS use rotational lines that happen to fall within the channels (MLS) or the tuned channel (SLS).
- MkIV uses data from the  $\nu_5$  band or the  $\nu_2$  band.
- FIRS-2 normally uses the  $\nu_9$  band, but can also use the  $\nu_5$  band.

# HCl retrievals

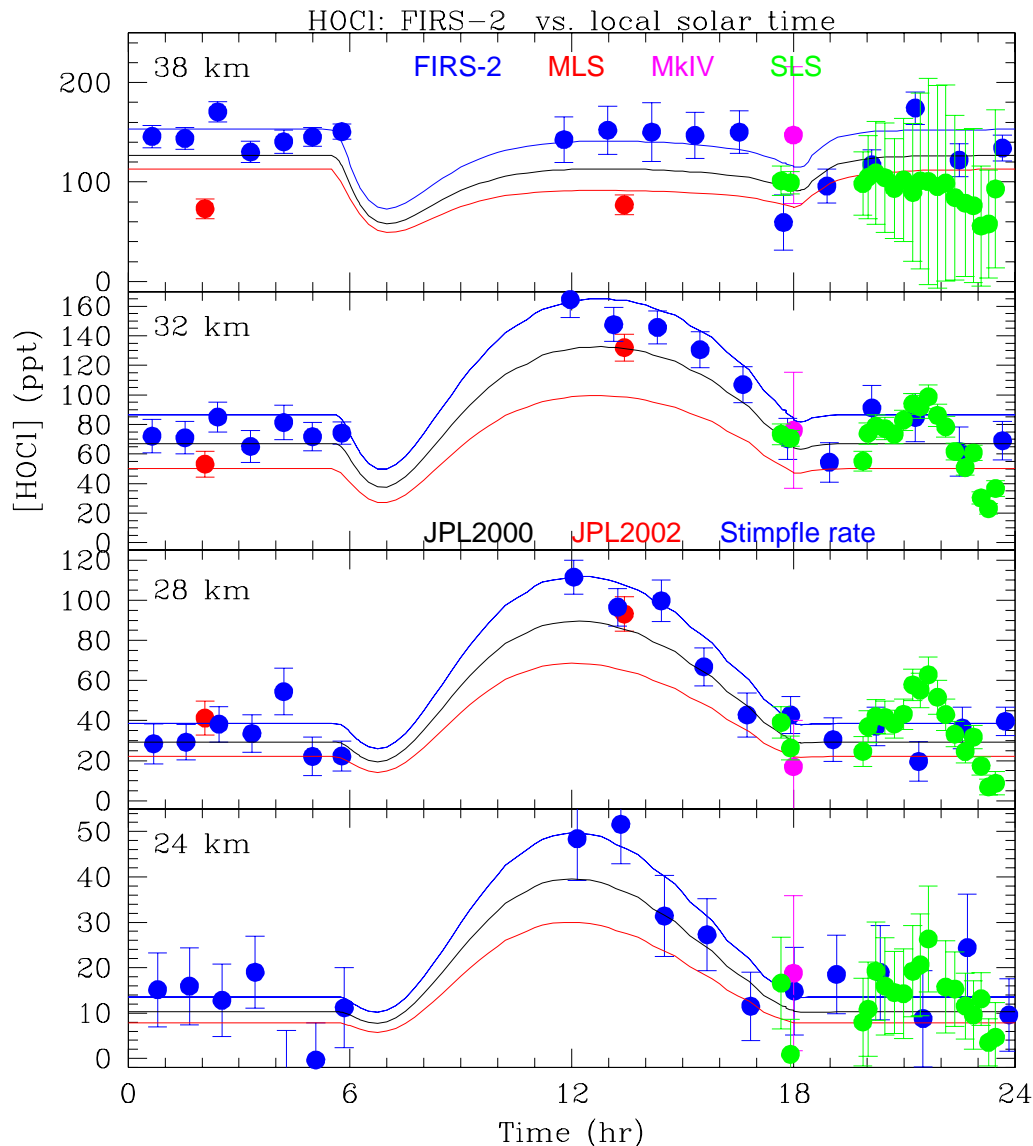


# HO<sub>x</sub> diurnal comparisons



- Comparisons with v2.1 MLS. OH is averaged over a 5 degree latitude band for one day. HO<sub>2</sub> is a broad average because only one day currently exists.
- MLS OH is slightly lower at the peak relative to the balloon data compared to the 2005 data.
- Model curves are constrained by FIRS-2 observations of H<sub>2</sub>O, O<sub>3</sub>, and N<sub>2</sub>O.

# HOCl diurnal comparisons



- MLS data is v1.5 data averaged over 15 days and a 5 degree latitude bin. We don't have enough v2.1 data yet to include here.
- FIRS-2 retrieves using 34 rotational line windows through the far infrared.
- MkIV retrieves using the  $\nu_2$  band in the infrared.
- SLS uses one rotational line in the submillimeter, similar to MLS.
- All flights of FIRS-2 and MkIV show similar comparisons to these model curves.
- The model curves differ mostly because of changes in the rate of  $\text{HO}_2 + \text{ClO}$ . See Laurie Kovalenko's poster for details of modeling and photochemical implications.
- This reaction has major implications for ozone loss in the lower stratosphere.